MULTIPLEXING OF PERIODIC CHANNEL STATE INFORMATION ON PHYSICAL UPLINK SHARED CHANNEL TOGETHER WITH HYBRID AUTOMATIC REPEAT REQUEST ACKNOWLEDGEMENT

CROSS REFERENCE TO RELATED APPLICATION

The present application claims priority to and the benefit of the filing date of U.S. Provisional Patent Application Ser. No. 62/617,128, filed Jan. 12, 2018, which is incorporated herein by reference in its entirety.

FIELD

The present disclosure relates to wireless communications, and in particular, to avoid data loss on the Physical Uplink Shared Channel due to periodic Channel State Information (CSI) reporting.

INTRODUCTION

Uplink Control Information (UCI) on Physical Uplink Shared Channel (PUSCH) in Long Term Evolution (LTE)

In Long Term Evolution (LTE), Uplink Control Information (UCI) on PUSCH is mapped to a resource grid as illustrated in FIG. **14**. In particular, FIG. **14** is a block diagram of a UCI mapping in LTE, where the x-axis shows Discrete Fourier Transform Spreading Orthogonal Frequency Division Multiplexing (DFTS-OFDM) symbols while the z-axis shows the time within a DFTS-OFDM symbol. Acknowledgement (ACK)/Negative ACK (NACK) is mapped to Discrete Fourier Transform Spreading Orthogonal Frequency Division Multiplexing (DFTS-OFDM) symbols closest to DeModulation Reference Signal (DM-RS), Rank Indicator (RI) is mapped to a next consecutive symbol. Precoder Matrix Index (PMI)/Channel Quality Information (CQI) is mapped to all DFTS-OFDM symbols (except those carrying DM-RS). ACK/NACK and RI are mapped close to DM-RS to benefit from the more current channel estimate.

UCI in New Radio (NR)

Channel State Information (CSI) in NR is split into two parts, CSI Part **1** and CSI Part**2** which are separately encoded. CSI Part **1** has a fixed (determined via Radio Resource Control (RRC) configuration) size and contains the length of CSI Part **2**, i.e., Part **1** must be decoded in order to determine the length of Part **2**.

PUSCH is rate matched around ACK/NACK ("AN") for more than 2 AN bits and punctured for 1 or 2 AN bits. In case of rate matching, AN is mapped, followed by CSI Part **1**, then followed by CSI Part **2**. For punctured AN, a certain amount of resources (resource elements) are reserved. CSI Part **1** is not mapped on the reserved resources, and CSI Part **1** mapping depends on the amount of reserved resources. FIG. **15** is block diagram of punctured acknowledgement/negative acknowledgement. CSI part **2** can be mapped on the reserved resources and also on resources after CSI part **1**. Data (UL-SCH) is mapped on remaining reserved resources and other remaining resources. AN is transmitted on the reserved resources, i.e., AN punctures PUSCH and CSI Part **2**.

SUMMARY

Some embodiments advantageously provide methods, systems, and apparatuses for helping avoid data loss on the PUSCH due to periodic CSI.

In some embodiments there is provided a method implemented in a wireless device. The method includes receiving a Downlink Control Information (DCI) message for scheduling transmission on a Physical Uplink Shared Channel (PUSCH). The DCI message does not contain an indication of how many resources to reserve for Hybrid Automatic Repeat Request (HARQ) bits. The method further includes reserving resources on the scheduled PUSCH for 2 HARQ bits.

In some embodiments there is provided a method implemented in a network node. The method includes scheduling the wireless device on a Physical Uplink Shared Channel (PUSCH) using a Downlink Control Information (DCI) message. The DCI message does not contain an indication of how many resources to reserve for Hybrid Automatic Repeat Request (HARQ) bits. The method further includes transmitting the DCI message to the wireless device.

In some embodiments a wireless device is provided. The wireless device is configured to communicate with a network node. The wireless device includes a radio interface and a processing circuitry. The processing circuit is configured to determine a scheduling of a Physical Uplink Shared Channel (PUSCH) based on a DCI message. The DCI message does not contain an indication of how many resources to reserve for Hybrid Automatic Repeat Request (HARQ) bits. The processing circuitry is further configured to reserve resources on the scheduled PUSCH for 2 HARQ bits.

In some embodiments a network node is provided. The network node is configured to communicate with a wireless device. The network node comprising a radio interface and comprising processing circuitry. The processing circuit is configured to schedule the wireless device on a Physical Uplink Shared Channel (PUSCH) using a Downlink Control Information (DCI) message. The DCI message not containing an indication of how many resources to reserve for Hybrid Automatic Repeat Request (HARQ) bits. The network node is further configured to transmit the DCI message to the wireless device.

The disclosure provides for one or more embodiments for avoiding data loss on the PUSCH due to periodic CSI and missed DL assignments on PUSCH that have been scheduled by fallback DCI. In one or more embodiments, the CSI is not multiplexed (i.e., drop) on PUSCH if the PUSCH is scheduled by a fallback DCI, i.e., DCI format 0_0. Therefore, the disclosure advantageously helps prevent data loss on PUSCH.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the present embodiments, and the attendant advantages and features thereof, will be more readily understood by reference to the following detailed description when considered in conjunction with the accompanying drawings wherein:

FIG. **1** is a schematic diagram of an exemplary network architecture illustrating a communication system connected via an intermediate network to a host computer according to the principles in the present disclosure;

FIG. **2** is a block diagram of a host computer communicating via a network node with a wireless device over an at least partially wireless connection according to some embodiments of the present disclosure;

FIG. **3** is a block diagram of an alternative embodiment of a host computer according to some embodiments of the present disclosure;